FINAL REPORT

LIMITED ENERGY STUDY, INSULATE BRICK BUILDINGS FORT LEONARD WOOD, MISSOURI

ENERGY ENGINEERING ANALYSIS PROGRAM (EEAP)

Prepared for

U.S. Army Corps of Engineers
Kansas City District
Kansas City, Missouri

Under

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By

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EXECUTIVE SUMMARY

AUTHORIZATION FOR STUDY

This study was conducted and this report prepared under Contract No. DACA01-94-D-0033, Delivery Order No. 0009, issued to E M C Engineers, Inc. (EMC) by the U.S. Army Engineer District, Mobile, on 17 October 1995. The delivery order was managed by the Kansas City District Corps of Engineers for Fort Leonard Wood, Missouri.

PURPOSE OF STUDY

The purpose of the Limited Energy Study, Insulate Brick Buildings, is to determine the economic feasibility of installing insulation in 100 existing brick buildings in the 600, 700, 800, and 1000 areas at Fort Leonard Wood, Missouri. The existing brick wall construction has an approximate R-value of 4 which is low for this geographic location.

APPROACH

The approach taken in performing the study included the following:

- Perform a field survey to document existing conditions of the building envelope such as exterior wall construction, window types, and roof construction; document the interior equipment and objects located on or near exterior walls (because equipment and objects must be relocated before wall insulation can be installed); interview the building managers for building information, occupancy schedules, lighting schedules, and equipment schedules; and record nameplate information of existing mechanical and electrical systems.

- Collect available information and data relative to historical energy usage, current utility rate schedules, building and equipment utilization, and existing energy conservation efforts.

- Review existing building drawings, as available.

- Determine an optimum R-value for exterior walls and roofs using a life cycle cost method; calculate the life cycle cost for installing wall and roof insulation in a typical building at the Fort Leonard Wood.

- Determine the life cycle costs for two types of wall insulation using fiberglass batt insulation and rigid board insulation, and fiberglass batt roof insulation.

- From the list of 100 buildings, determine a representative building from each of the ten building types. For instance, select one representative building out of the group of Mess Hall buildings.

- Evaluate the energy savings available if insulation is installed. Calculate the energy savings using computer energy simulations for the representative buildings, and extrapolate energy savings to identical and similar buildings.

- Evaluate the implementation costs for each of the wall insulation types for each representative building, and extrapolate the implementation costs to identical and similar buildings.

- Summarize energy savings and costs for each building, ranking the buildings by Savings-to-Investment Ratio (SIR) in order of priority.

- Perform LCCAs in accordance with the Energy Conservation Investment Program (ECIP) guidance, using the calculated energy savings and implementation costs.

- Prepare a written report documenting the existing conditions, wall insulation evaluation, energy savings analyses and calculations, implementation costs, recommendations, and conclusions.

METHOL OF ANALYSIS

The method of analysis used in this study included an optimum insulation analysis, energy savings calculations, determination of construction costs, and life cycle cost analysis (LCCA). The optimum insulation analysis was initially performed to determine the optimum thicknesses of insulation for use in the energy savings calculations. The energy savings calculations and construction costs were computed for the energy conservation opportunities (ECOs) evaluated. The energy savings and construction costs were used in the LCCAs to determine the Savings-to-Investment Ratios (SIRs) and Simple Paybacks for the ECOs.

Three categories of insulation construction were evaluated for the purpose of increasing the R-value of exterior walls and roofs. The R-value is a measure of thermal resistance to heat flow through a material. Installing insulation on the exterior walls and roof will increase the total R-values, and therefore will reduce heat loss and provide energy savings. The three categories of insulation evaluated for the walls and roof are as follows:

- Fiberglass batt insulation installed on walls
- Rigid insulation installed on walls
- Fiberglass batt insulation installed on roof.

Optimum Insulation Analysis

The life cycle costs were performed to determine the optimum wall R-values and the roof R-value that would be the most cost effective at Fort Leonard Wood. A representative building (Building 625 - Battalion Headquarters) was chosen as a model building to evaluate the life cycle costs. A life cycle cost was performed for each of the three categories of insulation construction and several thicknesses of insulation within each category. Table ES-1 below summarizes the life cycle costs for these three categories.

Table ES-1. Summary of Life Cycle Costs

Insulation Category	Life Cycle Costs ($)						
	Thicknesses of Fiberglass Batt Insulation Installed on Walls						
	0 in.	1 in.	3.5 in.	6 in.	9 in.	12 in.	-
Wall w/ Fiberglass Batt Insul.	53,449	64,526	61,767	62,414	69,024	70,827	-
	Thicknesses of Rigid Insulation Installed on Walls						
	0 in.	0.75 in.	1 in.	1.5 in.	2 in.	2.5 in.	3 in.
Wall w/ Rigid Insulation	53,449	59,364	59,157	59,120	59,513	60,195	60,753
	Thicknesses of Fiberglass Batt Insulation Installed on Roof						
	0 in.	1 in.	3.5 in.	6 in.	9 in.	12 in.	-
Roof w/ Fiberglass Batt Insul.	64,862	64,266	61,167	57,773	59,562	61,365	-

The lowest life cycle costs for insulation installed are the shaded items above. These life cycle costs represent the optimum thicknesses of insulation to be installed on the walls and roof. Table ES-2 below presents the optimum thicknesses of insulation.

Table ES-2. Optimum Insulation Thickness

Insulation Category	Optimum Insulation Thickness
Wall w/ Fiberglass Batt Insulation	3.5 in.
Wall w/ Rigid Insulation	1.5 in.
Roof w/ Fiberglass Batt Insulation	6.0 in.

The optimum wall insulation thicknesses are used in evaluating energy savings for the two types of wall insulation.

The roof insulation was evaluated for its optimum thickness to compare it to the existing thickness of roof insulation. The majority of the buildings have been retrofitted with 6 inches of fiberglass batt insulation, which is the optimum thickness for fiberglass batt roof insulation. Therefore, no further evaluation was performed for roof insulation.

Energy Savings Calculations

Building energy baselines were modeled on the BEACON energy analysis computer program for the ten representative buildings. The building energy baselines reflect the existing conditions of the buildings. The as-built drawings and field survey data provided the source for building inputs to the baselines.

The building energy baselines for the ten representative buildings were used to create ECO energy simulations. The energy simulation for ECO-1 is the baseline modified with the wall U-values of the additional fiberglass batt wall insulation. Similarly, the energy simulation for ECO-2 is the baseline modified with the wall U-values of the additional rigid wall insulation.

- The annual energy savings for natural gas and electricity for the representative buildings were calculated by subtracting the ECO energy use from the baseline energy use. The energy savings were then extrapolated to similar buildings by prorating the savings on a square foot basis.

- Construction costs were generated for the representative building ECOs. As-built drawings provided dimensions for the wall areas being renovated. Field survey data provided information on the quantity and type of interior equipment and objects required to be relocated. Costs for the renovations and relocations were obtained from the RS Means cost estimating guides and material manufacturers.

- The LCCAs were completed for the representative building ECOs. A 20 year economic life was used in the LCCAs. The discount factors were obtained from the Energy Price Indices and Discount Factors for Life-Cycle Cost Analysis 1996 - NISTIR 85-3273-10 (Rev. 10/95). The construction costs were entered into the LCCA calculation sheets.

  The investment costs for the representative buildings, calculated by the LCCAs, were extrapolated to similar buildings by prorating the costs on a square foot basis.

  The LCCAs also calculate SIRs and Simple Paybacks for the ECOs. The Energy Conservation Investment Program (ECIP) Guidance (dated January 1994) was used in the LCCAs. ECOs with SIRs greater than 1.25 and Simple Paybacks less than 10 years will qualify for funding. ECOs with SIRs less than 1.25 and Simple Paybacks greater than 10 years did not qualify for funding.

SUMMARY

The 100 buildings in this study were divided into ten groups on the basis of similar building use and function, with one representative building designated per group. The ten representative buildings were evaluated for two energy conservation opportunities (ECOs) each. ECO-1 represents the installation of fiberglass batt wall insulation, and ECO-2 represents the installation of rigid wall insulation. Energy savings, construction costs, and life cycle cost analyses (LCCAs) were calculated for each ECO.

The ten representative buildings are listed in Table ES-3 below.

Table ES-3. Representative Buildings for Field Survey

Bldg No.	Bldg Name	Sq Ft	Use
639	Branch PX	5,413	Retail Store
636	Brigade HQ	9,236	Administration
637	Chapel	8,949	Church and Administration
630	Mess Hall	13,280	Dining Facility
638	Administration Bldg	3,700	Administration
640	Gymnasium	20,425	Sports Facility
655	Administration/Supply	12,134	Administration and Supply
o51	Barracks, with A/C	40,990	Barracks
730	Barracks, without A/C	40,640	Barracks
625	Battalion HQ	6,163	Administration

The annual energy savings for the representative buildings were extrapolated to similar buildings in each building group. The extrapolation was performed on a square foot basis. Likewise, the construction costs were extrapolated to similar buildings in each building group.

The economic summary for ECO-1 and ECO-2 is presented in Table ES-4 beginning on page ES-6. This table ranks the ECOs from highest to lowest savings-to-investment ratio (SIR). The highest SIR calculated is 0.47 with a 35.5 year Simple Payback for Building 637, a Chapel building.

RECOMMENDATIONS

The ECOs presented in Table ES-4 have SIRs less than 1.25 and Simple Paybacks greater than 10 years. These ECOs do not qualify for funding under the ECIP and, therefore, are not recommended for implementation.

TABLE ES-4
ECONOMIC SUMMARY OF ECOs - RANKED BY SIR

BLDG NO.	BLDG NAME	BUILDING AREA (SF)	ECO NO.	NAT. GAS ENERGY SAVINGS (MBtu/yr)	ELEC. ENERGY SAVINGS (MBtu/yr)	TOTAL ENERGY SAVINGS (MBtu/yr)	ELEC. DEMAND S VINGS (kW)	NAT. GAS COST SAVINGS ($/yr)	ELEC. COST SAVINGS ($/yr)	ELEC. DEMAND COST SAVINGS ($/yr)	TOTAL ENERGY COST SAVINGS ($/yr)	TOTAL INVESTMENT ($)	DISCOUNTED SAVINGS ($)	SIMPLE PAYBACK (yrs)	SIR
637	Chapel	8,949	ECO 1	229.45	35.97	265.42	2.70	$1,216	$263	$200	$1,680	$59,688	$27,931	35.53	0.47
742	Chapel	8,949	ECO 1	229.45	35.97	265.42	2.70	$1,216	$263	$200	$1,680	$59,688	$27,931	35.53	0.47
843	Chapel	8,890	ECO 1	227.94	35.74	263.67	2.68	$1,208	$262	$199	$1,669	$59,295	$27,747	35.53	0.47
637	Chapel	8,949	ECO 2	232.76	37.24	270.00	2.80	$1,234	$273	$208	$1,714	$63,708	$28,470	37.17	0.45
742	Chapel	8,949	ECO 2	232.76	37.24	270.00	2.80	$1,234	$273	$208	$1,714	$63,708	$28,470	37.17	0.45
843	Chapel	8,890	ECO 2	231.23	36.99	268.22	2.78	$1,225	$271	$206	$1,703	$63,288	$28,282	37.17	0.45
639	Branch PX	5,413	ECO 1	49.11	8.26	57.37	1.30	$260	$60	$96	$417	$22,547	$6,757	54.04	0.30
835	Branch PX	6,240	ECO 1	56.61	9.52	66.13	1.50	$300	$70	$111	$481	$25,992	$7,789	54.04	0.30
835	Branch PX	6,240	ECO 2	60.00	10.27	70.27	1.50	$318	$75	$111	$504	$28,015	$8,183	55.54	0.29
639	Branch PX	5,413	ECO 2	52.05	8.91	60.96	1.30	$276	$65	$96	$438	$24,302	$7,099	55.54	0.29
630	Mess Hall	13,280	ECO 2	138.84	9.08	147.92	1.50	$736	$66	$111	$914	$55,748	$15,485	61.02	0.28
632	Mess Hall	13,280	ECO 2	138.84	9.08	147.92	1.50	$736	$66	$111	$914	$55,748	$15,485	61.02	0.28
653	Mess Hall	13,280	ECO 2	138.84	9.08	147.92	1.50	$736	$66	$111	$914	$55,748	$15,485	61.02	0.28
657	Mess Hall	13,280	ECO 2	138.84	9.08	147.92	1.50	$736	$66	$111	$914	$55,748	$15,485	61.02	0.28
735	Mess Hall	13,280	ECO 2	138.84	9.08	147.92	1.50	$736	$66	$111	$914	$55,748	$15,485	61.02	0.28
739	Mess Hall	13,280	ECO 2	138.84	9.08	147.92	1.50	$736	$66	$111	$914	$55,748	$15,485	61.02	0.28
749	Mess Hall	13,280	ECO 2	138.84	9.08	147.92	1.50	$736	$66	$111	$914	$55,748	$15,485	61.02	0.28
754	Mess Hall	13,280	ECO 2	138.84	9.08	147.92	1.50	$736	$66	$111	$914	$55,748	$15,485	61.02	0.28
820	Mess Hall	13,280	ECO 2	138.84	9.08	147.92	1.50	$736	$66	$111	$914	$55,748	$15,485	61.02	0.28
821	Mess Hall	13,280	ECO 2	138.84	9.08	147.92	1.50	$736	$66	$111	$914	$55,748	$15,485	61.02	0.28
836	Mess Hall	13,280	ECO 2	138.84	9.08	147.92	1.50	$736	$66	$111	$914	$55,748	$15,485	61.02	0.28
837	Mess Hall	13,280	ECO 2	138.84	9.08	147.92	1.50	$736	$66	$111	$914	$55,748	$15,485	61.02	0.28
1010	Mess Hall	13,280	ECO 2	138.84	9.08	147.92	1.50	$736	$66	$111	$914	$55,748	$15,485	61.02	0.28
1011	Mess Hall	13,280	ECO 2	138.84	9.08	147.92	1.50	$736	$66	$111	$914	$55,748	$15,485	61.02	0.28
1027	Mess Hall	13,280	ECO 2	138.84	9.08	147.92	1.50	$736	$66	$111	$914	$55,748	$15,485	61.02	0.28
630	Mess Hall	13,280	ECO 1	133.01	8.67	141.68	1.50	$705	$63	$111	$880	$54,215	$14,895	61.63	0.27
632	Mess Hall	13,280	ECO 1	133.01	8.67	141.68	1.50	$705	$63	$111	$880	$54,215	$14,895	61.63	0.27
653	Mess Hall	13,280	ECO 1	133.01	8.67	141.68	1.50	$705	$63	$111	$880	$54,215	$14,895	61.63	0.27
657	Mess Hall	13,280	ECO 1	133.01	8.67	141.68	1.50	$705	$63	$111	$880	$54,215	$14,895	61.63	0.27
735	Mess Hall	13,280	ECO 1	133.01	8.67	141.68	1.50	$705	$63	$111	$880	$54,215	$14,895	61.63	0.27
739	Mess Hall	13,280	ECO 1	133.01	8.67	141.68	1.50	$705	$63	$111	$880	$54,215	$14,895	61.63	0.27
749	Mess Hall	13,280	ECO 1	133.01	8.67	141.68	1.50	$705	$63	$111	$880	$54,215	$14,895	61.63	0.27
754	Mess Hall	13,280	ECO 1	133.01	8.67	141.68	1.50	$705	$63	$111	$880	$54,215	$14,895	61.63	0.27
820	Mess Hall	13,280	ECO 1	133.01	8.67	141.68	1.50	$705	$63	$111	$880	$54,215	$14,895	61.63	0.27
821	Mess Hall	13,280	ECO 1	133.01	8.67	141.68	1.50	$705	$63	$111	$880	$54,215	$14,895	61.63	0.27

TABLE ES-4
ECONOMIC SUMMARY OF ECOs - RANKED BY SIR

BLDG NO.	BLDG NAME	BUILDING AREA (SF)	ECO NO.	NAT. GAS ENERGY SAVINGS (MBtu/yr)	ELEC. ENERGY SAVINGS (MBtu/yr)	TOTAL ENERGY SAVINGS (MBtu/yr)	ELEC. DEMAND SA INGS (kW)	NAT. GAS COST SAVINGS ($/yr)	ELEC. COST SAVINGS ($/yr)	ELEC. DEMAND COST SAVINGS ($/yr)	TOTAL ENERGY COST SAVINGS ($/yr)	TOTAL INVESTMEN T ($)	DISCOUNTE D SAVINGS ($)	SIMPLE PAYBAC K (yrs)	SIR
836	Mess Hall	13,280	ECO 1	133.01	8.67	141.68	1.50	$705	$63	$111	$880	$54,215	$14,895	61.63	0.27
837	Mess Hall	13,280	ECO 1	133.01	8.67	141.68	1.50	$705	$63	$111	$880	$54,215	$14,895	61.63	0.27
1010	Mess Hall	13,280	ECO 1	133.01	8.67	141.68	1.50	$705	$63	$111	$880	$54,215	$14,895	61.63	0.27
1011	Mess Hall	13,280	ECO 1	133.01	8.67	141.68	1.50	$705	$63	$111	$880	$54,215	$14,895	61.63	0.27
1027	Mess Hall	13,280	ECO 1	133.01	8.67	141.68	1.50	$705	$63	$111	$880	$54,215	$14,895	61.63	0.27
744	Branch PX	6,240	ECO 1	56.61	9.52	66.13	1.50	$300	$70	$111	$481	$29,219	$7,789	60.75	0.27
744	Branch PX	6,240	ECO 2	60.00	10.27	70.27	1.50	$318	$75	$111	$504	$30,958	$8,183	61.38	0.26
626	Administration/Supply	12,155	ECO 2	128.11	0.00	128.11	0.00	$679	$0	$0	$679	$52,575	$12,059	77.43	0.23
733	Administration/Supply	12,155	ECO 2	128.11	0.00	128.11	0.00	$679	$0	$0	$679	$52,575	$12,059	77.43	0.23
734	Administration/Supply	12,155	ECO 2	128.11	0.00	128.11	0.00	$679	$0	$0	$679	$52,575	$12,059	77.43	0.23
751	Administration/Supply	12,155	ECO 2	128.11	0.00	128.11	0.00	$679	$0	$0	$679	$52,575	$12,059	77.43	0.23
752	Administration/Supply	12,155	ECO 2	128.11	0.00	128.11	0.00	$679	$0	$0	$679	$52,575	$12,059	77.43	0.23
823	Administration/Supply	12,155	ECO 2	128.11	0.00	128.11	0.00	$679	$0	$0	$679	$52,575	$12,059	77.43	0.23
824	Administration/Supply	12,155	ECO 2	128.11	0.00	128.11	0.00	$679	$0	$0	$679	$52,575	$12,059	77.43	0.23
840	Administration/Supply	12,155	ECO 2	128.11	0.00	128.11	0.00	$679	$0	$0	$679	$52,575	$12,059	77.43	0.23
841	Administration/Supply	12,155	ECO 2	128.11	0.00	128.11	0.00	$679	$0	$0	$679	$52,575	$12,059	77.43	0.23
1006	Administration/Supply	12,155	ECO 2	128.11	0.00	128.11	0.00	$679	$0	$0	$679	$52,575	$12,059	77.43	0.23
1007	Administration/Supply	12,155	ECO 2	128.11	0.00	128.11	0.00	$679	$0	$0	$679	$52,575	$12,059	77.43	0.23
1025	Administration/Supply	12,155	ECO 2	128.11	0.00	128.11	0.00	$679	$0	$0	$679	$52,575	$12,059	77.43	0.23
633	Administration/Supply	12,134	ECO 2	127.89	0.00	127.89	0.00	$678	$0	$0	$678	$52,484	$12,038	77.43	0.23
655	Administration/Supply	12,134	ECO 2	127.89	0.00	127.89	0.00	$678	$0	$0	$678	$52,484	$12,038	77.43	0.23
656	Administration/Supply	12,134	ECO 2	127.89	0.00	127.89	0.00	$678	$0	$0	$678	$52,484	$12,038	77.43	0.23
626	Administration/Supply	12,155	ECO 1	122.60	0.00	122.60	0.00	$650	$0	$0	$650	$51,082	$11,540	78.61	0.23
733	Administration/Supply	12,155	ECO 1	122.60	0.00	122.60	0.00	$650	$0	$0	$650	$51,082	$11,540	78.61	0.23
734	Administration/Supply	12,155	ECO 1	122.60	0.00	122.60	0.00	$650	$0	$0	$650	$51,082	$11,540	78.61	0.23
751	Administration/Supply	12,155	ECO 1	122.60	0.00	122.60	0.00	$650	$0	$0	$650	$51,082	$11,540	78.61	0.23
752	Administration/Supply	12,155	ECO 1	122.60	0.00	122.60	0.00	$650	$0	$0	$650	$51,082	$11,540	78.61	0.23
823	Administration/Supply	12,155	ECO 1	122.60	0.00	122.60	0.00	$650	$0	$0	$650	$51,082	$11,540	78.61	0.23
824	Administration/Supply	12,155	ECO 1	122.60	0.00	122.60	0.00	$650	$0	$0	$650	$51,082	$11,540	78.61	0.23
840	Administration/Supply	12,155	ECO 1	122.60	0.00	122.60	0.00	$650	$0	$0	$650	$51,082	$11,540	78.61	0.23
841	Administration/Supply	12,155	ECO 1	122.60	0.00	122.60	0.00	$650	$0	$0	$650	$51,082	$11,540	78.61	0.23
1006	Administration/Supply	12,155	ECO 1	122.60	0.00	122.60	0.00	$650	$0	$0	$650	$51,082	$11,540	78.61	0.23
1007	Administration/Supply	12,155	ECO 1	122.60	0.00	122.60	0.00	$650	$0	$0	$650	$51,082	$11,540	78.61	0.23
1025	Administration/Supply	12,155	ECO 1	122.60	0.00	122.60	0.00	$650	$0	$0	$650	$51,082	$11,540	78.61	0.23
633	Administration/Supply	12,134	ECO 1	122.39	0.00	122.39	0.00	$649	$0	$0	$649	$50,994	$11,520	78.61	0.23

TABLE ES-4
ECONOMIC SUMMARY OF ECOs - RANKED BY SIR

BLDG NO.	BLDG NAME	BUILDING AREA (SF)	ECO NO.	NAT. GAS ENERGY SAVINGS (MBtu/yr)	ELEC. ENERGY SAVINGS (MBtu/yr)	TOTAL ENERGY SAVINGS (MBtu/yr)	ELEC. DEMAND SAVINGS (kW)	NAT. GAS COST SAVINGS ($/yr)	ELEC. COST SAVINGS ($/yr)	ELEC. DEMAND COST SAVINGS ($/yr)	TOTAL ENERGY COST SAVINGS ($/yr)	TOTAL INVESTMENT ($)	DISCOUNTED SAVINGS ($)	SIMPLE PAYBACK (yrs)	SIR
655	Administration/Supply	12,134	ECO 1	122.39	0.00	122.39	0.00	$649	$0	$0	$649	$50,994	$11,520	78.61	0.23
656	Administration/Supply	12,134	ECO 1	122.39	0.00	122.39	0.00	$649	$0	$0	$649	$50,994	$11,520	78.61	0.23
627	Barracks, with A/C	40,640	ECO 2	351.63	19.15	370.78	4.66	$1,864	$140	$346	$2,350	$180,374	$39,692	76.76	0.22
628	Barracks, with A/C	40,640	ECO 2	351.63	19.15	370.78	4.66	$1,864	$140	$346	$2,350	$180,374	$39,692	76.76	0.22
629	Barracks, with A/C	40,640	ECO 2	351.63	19.15	370.78	4.66	$1,864	$140	$346	$2,350	$180,374	$39,692	76.76	0.22
634	Barracks, with A/C	40,990	ECO 2	354.66	19.32	373.98	4.70	$1,880	$141	$349	$2,370	$181,928	$40,034	76.76	0.22
635	Barracks, with A/C	40,990	ECO 2	354.66	19.32	373.98	4.70	$1,880	$141	$349	$2,370	$181,928	$40,034	76.76	0.22
651	Barracks, with A/C	40,990	ECO 2	354.66	19.32	373.98	4.70	$1,880	$141	$349	$2,370	$181,928	$40,034	76.76	0.22
652	Barracks, with A/C	40,990	ECO 2	354.66	19.32	373.98	4.70	$1,880	$141	$349	$2,370	$181,928	$40,034	76.76	0.22
654	Barracks, with A/C	40,990	ECO 2	354.66	19.32	373.98	4.70	$1,880	$141	$349	$2,370	$181,928	$40,034	76.76	0.22
659	Barracks, with A/C	40,990	ECO 2	354.66	19.32	373.98	4.70	$1,880	$141	$349	$2,370	$181,928	$40,034	76.76	0.22
660	Barracks, with A/C	40,990	ECO 2	354.66	19.32	373.98	4.70	$1,880	$141	$349	$2,370	$181,928	$40,034	76.76	0.22
1012	Barracks, with A/C	40,640	ECO 2	351.63	19.15	370.78	4.66	$1,864	$140	$346	$2,350	$180,374	$39,692	76.76	0.22
1013	Barracks, with A/C	40,640	ECO 2	351.63	19.15	370.78	4.66	$1,864	$140	$346	$2,350	$180,374	$39,692	76.76	0.22
1014	Barracks, with A/C	40,640	ECO 2	351.63	19.15	370.78	4.66	$1,864	$140	$346	$2,350	$180,374	$39,692	76.76	0.22
1015	Barracks, with A/C	40,640	ECO 2	351.63	19.15	370.78	4.66	$1,864	$140	$346	$2,350	$180,374	$39,692	76.76	0.22
1016	Barracks, with A/C	40,640	ECO 2	351.63	19.15	370.78	4.66	$1,864	$140	$346	$2,350	$180,374	$39,692	76.76	0.22
1028	Barracks, with A/C	40,640	ECO 2	351.63	19.15	370.78	4.66	$1,864	$140	$346	$2,350	$180,374	$39,692	76.76	0.22
1029	Barracks, with A/C	40,640	ECO 2	351.63	19.15	370.78	4.66	$1,864	$140	$346	$2,350	$180,374	$39,692	76.76	0.22
627	Barracks, with A/C	40,640	ECO 1	332.42	18.07	350.49	4.46	$1,762	$132	$331	$2,225	$175,112	$37,576	78.69	0.21
628	Barracks, with A/C	40,640	ECO 1	332.42	18.07	350.49	4.46	$1,762	$132	$331	$2,225	$175,112	$37,576	78.69	0.21
629	Barracks, with A/C	40,640	ECO 1	332.42	18.07	350.49	4.46	$1,762	$132	$331	$2,225	$175,112	$37,576	78.69	0.21
634	Barracks, with A/C	40,990	ECO 1	335.28	18.23	353.51	4.50	$1,777	$133	$334	$2,244	$176,620	$37,899	78.69	0.21
635	Barracks, with A/C	40,990	ECO 1	335.28	18.23	353.51	4.50	$1,777	$133	$334	$2,244	$176,620	$37,899	78.69	0.21
651	Barracks, with A/C	40,990	ECO 1	335.28	18.23	353.51	4.50	$1,777	$133	$334	$2,244	$176,620	$37,899	78.69	0.21
652	Barracks, with A/C	40,990	ECO 1	335.28	18.23	353.51	4.50	$1,777	$133	$334	$2,244	$176,620	$37,899	78.69	0.21
654	Barracks, with A/C	40,990	ECO 1	335.28	18.23	353.51	4.50	$1,777	$133	$334	$2,244	$176,620	$37,899	78.69	0.21
659	Barracks, with A/C	40,990	ECO 1	335.28	18.23	353.51	4.50	$1,777	$133	$334	$2,244	$176,620	$37,899	78.69	0.21
660	Barracks, with A/C	40,990	ECO 1	335.28	18.23	353.51	4.50	$1,777	$133	$334	$2,244	$176,620	$37,899	78.69	0.21
1012	Barracks, with A/C	40,640	ECO 1	332.42	18.07	350.49	4.46	$1,762	$132	$331	$2,225	$175,112	$37,576	78.69	0.21
1013	Barracks, with A/C	40,640	ECO 1	332.42	18.07	350.49	4.46	$1,762	$132	$331	$2,225	$175,112	$37,576	78.69	0.21
1014	Barracks, with A/C	40,640	ECO 1	332.42	18.07	350.49	4.46	$1,762	$132	$331	$2,225	$175,112	$37,576	78.69	0.21
1015	Barracks, with A/C	40,640	ECO 1	332.42	18.07	350.49	4.46	$1,762	$132	$331	$2,225	$175,112	$37,576	78.69	0.21
1016	Barracks, with A/C	40,640	ECO 1	332.42	18.07	350.49	4.46	$1,762	$132	$331	$2,225	$175,112	$37,576	78.69	0.21
1028	Barracks, with A/C	40,640	ECO 1	332.42	18.07	350.49	4.46	$1,762	$132	$331	$2,225	$175,112	$37,576	78.69	0.21

TABLE ES-4
ECONOMIC SUMMARY OF ECOs - RANKED BY SIR

BLDG NO.	BLDG NAME	BUILDING AREA (SF)	ECO NO.	NAT. GAS ENERGY SAVINGS (MBtu/yr)	ELEC. ENERGY SAVINGS (MBtu/yr)	TOTAL ENERGY SAVINGS (MBtu/yr)	ELEC. DEMAND S/ VINGS (kW)	NAT. GAS COST SAVINGS ($/yr)	ELEC. COST SAVINGS ($/yr)	ELEC. DEMAND COST SAVINGS ($/yr)	TOTAL ENERGY COST SAVINGS ($/yr)	TOTAL INVESTMENT ($)	DISCOUNTED SAVINGS ($)	SIMPLE PAYBACK (yrs)	SIR
1029	Barracks, with A/C	40,640	ECO 1	332.42	18.07	350.49	4.46	$1,762	$132	$331	$2,225	$175,112	$37,576	78.69	0.21
625	Battalion HQ	6,163	ECO 2	70.48	7.75	78.23	0.00	$374	$57	$0	$430	$38,019	$7,417	88.36	0.20
631	Battalion HQ	6,163	ECO 2	70.48	7.75	78.23	0.00	$374	$57	$0	$430	$38,019	$7,417	88.36	0.20
650	Battalion HQ	6,163	ECO 2	70.48	7.75	78.23	0.00	$374	$57	$0	$430	$38,019	$7,417	88.36	0.20
658	Battalion HQ	6,163	ECO 2	70.48	7.75	78.23	0.00	$374	$57	$0	$430	$38,019	$7,417	88.36	0.20
732	Battalion HQ	6,163	ECO 2	70.48	7.75	78.23	0.00	$374	$57	$0	$430	$38,019	$7,417	88.36	0.20
740	Battalion HQ	6,163	ECO 2	70.48	7.75	78.23	0.00	$374	$57	$0	$430	$38,019	$7,417	88.36	0.20
750	Battalion HQ	6,163	ECO 2	70.48	7.75	78.23	0.00	$374	$57	$0	$430	$38,019	$7,417	88.36	0.20
753	Battalion HQ	6,163	ECO 2	70.48	7.75	78.23	0.00	$374	$57	$0	$430	$38,019	$7,417	88.36	0.20
822	Battalion HQ	6,163	ECO 2	70.48	7.75	78.23	0.00	$374	$57	$0	$430	$38,019	$7,417	88.36	0.20
825	Battalion HQ	6,163	ECO 2	70.48	7.75	78.23	0.00	$374	$57	$0	$430	$38,019	$7,417	88.36	0.20
838	Battalion HQ	6,163	ECO 2	70.48	7.75	78.23	0.00	$374	$57	$0	$430	$38,019	$7,417	88.36	0.20
842	Battalion HQ	6,163	ECO 2	70.48	7.75	78.23	0.00	$374	$57	$0	$430	$38,019	$7,417	88.36	0.20
1008	Battalion HQ	6,163	ECO 2	70.48	7.75	78.23	0.00	$374	$57	$0	$430	$38,019	$7,417	88.36	0.20
1009	Battalion HQ	6,163	ECO 2	70.48	7.75	78.23	0.00	$374	$57	$0	$430	$38,019	$7,417	88.36	0.20
1022	Battalion HQ	6,163	ECO 2	70.48	7.75	78.23	0.00	$374	$57	$0	$430	$38,019	$7,417	88.36	0.20
1023	Battalion HQ	6,163	ECO 2	70.48	7.75	78.23	0.00	$374	$57	$0	$430	$38,019	$7,417	88.36	0.20
625	Battalion HQ	6,163	ECO 1	67.50	7.30	74.80	0.00	$358	$53	$0	$411	$37,132	$7,091	90.30	0.19
631	Battalion HQ	6,163	ECO 1	67.50	7.30	74.80	0.00	$358	$53	$0	$411	$37,132	$7,091	90.30	0.19
650	Battalion HQ	6,163	ECO 1	67.50	7.30	74.80	0.00	$358	$53	$0	$411	$37,132	$7,091	90.30	0.19
658	Battalion HQ	6,163	ECO 1	67.50	7.30	74.80	0.00	$358	$53	$0	$411	$37,132	$7,091	90.30	0.19
732	Battalion HQ	6,163	ECO 1	67.50	7.30	74.80	0.00	$358	$53	$0	$411	$37,132	$7,091	90.30	0.19
740	Battalion HQ	6,163	ECO 1	67.50	7.30	74.80	0.00	$358	$53	$0	$411	$37,132	$7,091	90.30	0.19
750	Battalion HQ	6,163	ECO 1	67.50	7.30	74.80	0.00	$358	$53	$0	$411	$37,132	$7,091	90.30	0.19
753	Battalion HQ	6,163	ECO 1	67.50	7.30	74.80	0.00	$358	$53	$0	$411	$37,132	$7,091	90.30	0.19
822	Battalion HQ	6,163	ECO 1	67.50	7.30	74.80	0.00	$358	$53	$0	$411	$37,132	$7,091	90.30	0.19
825	Battalion HQ	6,163	ECO 1	67.50	7.30	74.80	0.00	$358	$53	$0	$411	$37,132	$7,091	90.30	0.19
838	Battalion HQ	6,163	ECO 1	67.50	7.30	74.80	0.00	$358	$53	$0	$411	$37,132	$7,091	90.30	0.19
842	Battalion HQ	6,163	ECO 1	67.50	7.30	74.80	0.00	$358	$53	$0	$411	$37,132	$7,091	90.30	0.19
1008	Battalion HQ	6,163	ECO 1	67.50	7.30	74.80	0.00	$358	$53	$0	$411	$37,132	$7,091	90.30	0.19
1009	Battalion HQ	6,163	ECO 1	67.50	7.30	74.80	0.00	$358	$53	$0	$411	$37,132	$7,091	90.30	0.19
1022	Battalion HQ	6,163	ECO 1	67.50	7.30	74.80	0.00	$358	$53	$0	$411	$37,132	$7,091	90.30	0.19
1023	Battalion HQ	6,163	ECO 1	67.50	7.30	74.80	0.00	$358	$53	$0	$411	$37,132	$7,091	90.30	0.19
638	Administration Bldg	3,700	ECO 2	34.81	5.56	40.37	0.00	$184	$41	$0	$225	$21,836	$3,839	96.95	0.18
743	Administration Bldg	3,700	ECO 2	34.81	5.56	40.37	0.00	$184	$41	$0	$225	$21,836	$3,839	96.95	0.18

TABLE ES-4
ECONOMIC SUMMARY OF ECOs - RANKED BY SIR

BLDG NO.	BLDG NAME	BUILDING AREA (SF)	ECO NO.	NAT. GAS ENERGY SAVINGS (MBtu/yr)	ELEC. ENERGY SAVINGS (MBtu/yr)	TOTAL ENERGY SAVINGS (MBtu/yr)	ELEC. DEMAND SAVINGS (kW)	NAT. GAS COST SAVINGS ($/yr)	ELEC. COST SAVINGS ($/yr)	ELEC. DEMAND COST SAVINGS ($/yr)	TOTAL ENERGY COST SAVINGS ($/yr)	TOTAL INVESTMENT ($)	DISCOUNTED SAVINGS ($)	SIMPLE PAYBACK (yrs)	SIR
832	Administration Bldg	3,700	ECO 2	34.81	5.56	40.37	0.00	$184	$41	$0	$225	$21,836	$3,839	96.95	0.18
638	Administration Bldg	3,700	ECO 1	33.13	5.26	38.39	0.00	$176	$38	$0	$214	$21,565	$3,649	100.74	0.17
743	Administration Bldg	3,700	ECO 1	33.13	5.26	38.39	0.00	$176	$38	$0	$214	$21,565	$3,649	100.74	0.17
832	Administration Bldg	3,700	ECO 1	33.13	5.26	38.39	0.00	$176	$38	$0	$214	$21,565	$3,649	100.74	0.17
730	Barracks, without A/C	40,640	ECO 2	278.90	0.00	278.90	0.00	$1,478	$0	$0	$1,478	$183,884	$26,252	124.40	0.14
731	Barracks, without A/C	40,640	ECO 2	278.90	0.00	278.90	0.00	$1,478	$0	$0	$1,478	$183,884	$26,252	124.40	0.14
736	Barracks, without A/C	40,640	ECO 2	278.90	0.00	278.90	0.00	$1,478	$0	$0	$1,478	$183,884	$26,252	124.40	0.14
737	Barracks, without A/C	40,640	ECO 2	278.90	0.00	278.90	0.00	$1,478	$0	$0	$1,478	$183,884	$26,252	124.40	0.14
738	Barracks, without A/C	40,640	ECO 2	278.90	0.00	278.90	0.00	$1,478	$0	$0	$1,478	$183,884	$26,252	124.40	0.14
747	Barracks, without A/C	40,640	ECO 2	278.90	0.00	278.90	0.00	$1,478	$0	$0	$1,478	$183,884	$26,252	124.40	0.14
748	Barracks, without A/C	40,640	ECO 2	278.90	0.00	278.90	0.00	$1,478	$0	$0	$1,478	$183,884	$26,252	124.40	0.14
755	Barracks, without A/C	40,640	ECO 2	278.90	0.00	278.90	0.00	$1,478	$0	$0	$1,478	$183,884	$26,252	124.40	0.14
756	Barracks, without A/C	40,640	ECO 2	278.90	0.00	278.90	0.00	$1,478	$0	$0	$1,478	$183,884	$26,252	124.40	0.14
757	Barracks, without A/C	40,640	ECO 2	278.90	0.00	278.90	0.00	$1,478	$0	$0	$1,478	$183,884	$26,252	124.40	0.14
815	Barracks, without A/C	40,640	ECO 2	278.90	0.00	278.90	0.00	$1,478	$0	$0	$1,478	$183,884	$26,252	124.40	0.14
816	Barracks, without A/C	40,640	ECO 2	278.90	0.00	278.90	0.00	$1,478	$0	$0	$1,478	$183,884	$26,252	124.40	0.14
817	Barracks, without A/C	40,640	ECO 2	278.90	0.00	278.90	0.00	$1,478	$0	$0	$1,478	$183,884	$26,252	124.40	0.14
818	Barracks, without A/C	40,640	ECO 2	278.90	0.00	278.90	0.00	$1,478	$0	$0	$1,478	$183,884	$26,252	124.40	0.14
819	Barracks, without A/C	40,640	ECO 2	278.90	0.00	278.90	0.00	$1,478	$0	$0	$1,478	$183,884	$26,252	124.40	0.14
827	Barracks, without A/C	40,640	ECO 2	278.90	0.00	278.90	0.00	$1,478	$0	$0	$1,478	$183,884	$26,252	124.40	0.14
828	Barracks, without A/C	40,640	ECO 2	278.90	0.00	278.90	0.00	$1,478	$0	$0	$1,478	$183,884	$26,252	124.40	0.14
829	Barracks, without A/C	40,640	ECO 2	278.90	0.00	278.90	0.00	$1,478	$0	$0	$1,478	$183,884	$26,252	124.40	0.14
830	Barracks, without A/C	40,640	ECO 2	278.90	0.00	278.90	0.00	$1,478	$0	$0	$1,478	$183,884	$26,252	124.40	0.14
831	Barracks, without A/C	40,640	ECO 2	278.90	0.00	278.90	0.00	$1,478	$0	$0	$1,478	$183,884	$26,252	124.40	0.14
730	Barracks, without A/C	40,640	ECO 1	261.73	0.00	261.73	0.00	$1,387	$0	$0	$1,387	$178,577	$24,636	128.73	0.14
731	Barracks, without A/C	40,640	ECO 1	261.73	0.00	261.73	0.00	$1,387	$0	$0	$1,387	$178,577	$24,636	128.73	0.14
736	Barracks, without A/C	40,640	ECO 1	261.73	0.00	261.73	0.00	$1,387	$0	$0	$1,387	$178,577	$24,636	128.73	0.14
737	Barracks, without A/C	40,640	ECO 1	261.73	0.00	261.73	0.00	$1,387	$0	$0	$1,387	$178,577	$24,636	128.73	0.14
738	Barracks, without A/C	40,640	ECO 1	261.73	0.00	261.73	0.00	$1,387	$0	$0	$1,387	$178,577	$24,636	128.73	0.14
747	Barracks, without A/C	40,640	ECO 1	261.73	0.00	261.73	0.00	$1,387	$0	$0	$1,387	$178,577	$24,636	128.73	0.14
748	Barracks, without A/C	40,640	ECO 1	261.73	0.00	261.73	0.00	$1,387	$0	$0	$1,387	$178,577	$24,636	128.73	0.14
755	Barracks, without A/C	40,640	ECO 1	261.73	0.00	261.73	0.00	$1,387	$0	$0	$1,387	$178,577	$24,636	128.73	0.14
756	Barracks, without A/C	40,640	ECO 1	261.73	0.00	261.73	0.00	$1,387	$0	$0	$1,387	$178,577	$24,636	128.73	0.14
757	Barracks, without A/C	40,640	ECO 1	261.73	0.00	261.73	0.00	$1,387	$0	$0	$1,387	$178,577	$24,636	128.73	0.14
815	Barracks, without A/C	40,640	ECO 1	261.73	0.00	261.73	0.00	$1,387	$0	$0	$1,387	$178,577	$24,636	128.73	0.14

TABLE ES-1
ECONOMIC SUMMARY OF ECOs - RANKED BY SIR

BLDG NO.	BLDG NAME	BUILDING AREA (SF)	ECO NO.	NAT. GAS ENERGY SAVINGS (MBtu/yr)	ELEC. ENERGY SAVINGS (MBtu/yr)	TOTAL ENERGY SAVINGS (MBtu/yr)	ELEC. DEMAND SAVINGS (kW)	NAT. GAS COST SAVINGS ($/yr)	ELEC. COST SAVINGS ($/yr)	ELEC. DEMAND COST SAVINGS ($/yr)	TOTAL ENERGY COST SAVINGS ($/yr)	TOTAL INVESTMENT ($)	DISCOUNTED SAVINGS ($)	SIMPLE PAYBACK (yrs)	SIR
816	Barracks, without A/C	40,640	ECO 1	261.73	0.00	261.73	0.00	$1,387	$0	$0	$1,387	$178,577	$24,636	128.73	0.14
817	Barracks, without A/C	40,640	ECO 1	261.73	0.00	261.73	0.00	$1,387	$0	$0	$1,387	$178,577	$24,636	128.73	0.14
818	Barracks, without A/C	40,640	ECO 1	261.73	0.00	261.73	0.00	$1,387	$0	$0	$1,387	$178,577	$24,636	128.73	0.14
819	Barracks, without A/C	40,640	ECO 1	261.73	0.00	261.73	0.00	$1,387	$0	$0	$1,387	$178,577	$24,636	128.73	0.14
827	Barracks, without A/C	40,640	ECO 1	261.73	0.00	261.73	0.00	$1,387	$0	$0	$1,387	$178,577	$24,636	128.73	0.14
828	Barracks, without A/C	40,640	ECO 1	261.73	0.00	261.73	0.00	$1,387	$0	$0	$1,387	$178,577	$24,636	128.73	0.14
829	Barracks, without A/C	40,640	ECO 1	261.73	0.00	261.73	0.00	$1,387	$0	$0	$1,387	$178,577	$24,636	128.73	0.14
830	Barracks, without A/C	40,640	ECO 1	261.73	0.00	261.73	0.00	$1,387	$0	$0	$1,387	$178,577	$24,636	128.73	0.14
831	Barracks, without A/C	40,640	ECO 1	261.73	0.00	261.73	0.00	$1,387	$0	$0	$1,387	$178,577	$24,636	128.73	0.14
640	Gymnasium	20,425	ECO 1	160.33	0.00	160.33	0.00	$850	$0	$0	$850	$129,351	$15,092	152.22	0.12
746	Gymnasium	20,425	ECO 1	160.33	0.00	160.33	0.00	$850	$0	$0	$850	$129,351	$15,092	152.22	0.12
826	Gymnasium	20,425	ECO 1	160.33	0.00	160.33	0.00	$850	$0	$0	$850	$129,351	$15,092	152.22	0.12
640	Gymnasium	20,425	ECO 2	166.97	0.00	166.97	0.00	$885	$0	$0	$885	$139,097	$15,717	157.18	0.11
746	Gymnasium	20,425	ECO 2	166.97	0.00	166.97	0.00	$885	$0	$0	$885	$139,097	$15,717	157.18	0.11
826	Gymnasium	20,425	ECO 2	166.97	0.00	166.97	0.00	$885	$0	$0	$885	$139,097	$15,717	157.18	0.11
844	Brigade HQ	9,890	ECO 1	45.94	12.32	58.25	0.86	$243	$90	$64	$397	$61,881	$6,425	155.79	0.10
1018	Brigade HQ	9,890	ECO 1	45.94	12.32	58.25	0.86	$243	$90	$64	$397	$61,881	$6,425	155.79	0.10
636	Brigade HQ	9,236	ECO 1	42.90	11.50	54.40	0.80	$227	$84	$59	$371	$57,789	$6,000	155.79	0.10
741	Brigade HQ	9,236	ECO 1	42.90	11.50	54.40	0.80	$227	$84	$59	$371	$57,789	$6,000	155.79	0.10
844	Brigade HQ	9,890	ECO 2	48.27	12.83	61.10	0.86	$256	$94	$64	$413	$65,384	$6,696	158.19	0.10
1018	Brigade HQ	9,890	ECO 2	48.27	12.83	61.10	0.86	$256	$94	$64	$413	$65,384	$6,696	158.19	0.10
636	Brigade HQ	9,236	ECO 2	45.08	11.98	57.06	0.80	$239	$88	$59	$386	$61,061	$6,253	158.19	0.10
741	Brigade HQ	9,236	ECO 2	45.08	11.98	57.06	0.80	$239	$88	$59	$386	$61,061	$6,253	158.19	0.10

APPENDIX A

ENERGY COST ANALYSIS